191b Strategies to Enhance Capillary Formation inside Biomaterials: a Computational Study

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Control over angiogenesis (formation of new capillaries from preexisting vessels) is often a crucial requirement for implantable porous biomaterials serving as scaffolds for tissue regeneration. Angiogenesis is influenced by the transport of chemoattractants (e.g., cytokines) through the implant. To investigate this influence, we have developed a computational model of capillary formation based on endothelial cell migration by modeling the random motion of sprout tips biased along spatially and temporally evolving concentration gradients of chemoattractant. The model focuses on the effect of chemoattractant transport inside the 2D porous domain on the directed migration of sprouts to test several chemical and physical strategies to stimulate and control angiogenesis. We consider a porous membrane which is located between the primary vessel and a line source of chemoattractant. We assess vascular networks in three modes of chemoattractant production: (1) only a line source; (2) a line source plus randomly dispersed chemoattractant sources on the pore walls; and (3) a line source plus controlled release of chemoattractant from the pore boundaries. Results show that while case 2 and 3 lead to substantial increase in the number of vessels, this increase depends on the relative rates at which line source and embedded sources or pore boundaries produce chemoattractant. The newly formed capillary network in case 2 is highly localized around the embedded sources. However, in case 3 vessels diffuse more homogeneously which leads to higher coverage of available surface area inside the porous membrane. In addition, the duration at which we engineer the embedded sources or pore boundaries to release chemoattractant determines the morphology of capillary network. While a longer release duration leads to dense network of newly formed vessels near the primary vessel, it hinders further vessel penetration inside the porous membrane. Therefore, in both case 2 and 3, there is an optimum release duration which leads to deeper penetration of newly formed vessels inside the membrane. It is hoped that insights from this study will aid in the design of materials with optimal structural and chemical properties to facilitate controlled angiogenesis.